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Fostering Students' Creativity through Van Hiele's 5 phase-Based Tangram Activities

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Abstract

The aim of this study was to determine whether Van Hiele's 5 phase-based tangrams activities could help to foster creativity among Grade Three primary school students. Students' creativity was investigated in terms of Torrance's Figural Test of creative thinking: Fluency, Originality, Elaboration, Abstractness of title, and Resistance to a premature closure. The study further examined students' responses to learning experience in tangram activities. A pre-test and post-test single group experimental design was employed in the study. This research design involved assessment on the students' creativity based on the figural constructing task which was implemented prior and subsequent to the intervention. A total of 144 Grade Three students took part in the study. The students learned Two-dimensional geometry and Symmetry through the Van Hiele's 5 phases of learning using tangram. The intervention took place for 3 hours. Paired samples t-tests which compared the mean scores of pre- and post- figural test were computed to determine if a significant difference existed. The results showed that there were significant differences in mean scores between pre- and post-figural test. The in-depth analysis about the five dimensions of Torrance's creativity found that the applied intervention was only significant in improving students' elaboration, no significant changes in students' fluency and abstractness of title, and significant dropping performance in originality and resistance to premature closure. Generally, students felt that the tangram activities had provided an opportunity for them to think creatively. In conclusion, this study shows that the tangram, when integrated with van Hiele's five Phases of learning is able to foster student's creativity in geometric lessons.

Keywords: creativity, geometry, tangrams, Torrance's Figural Test of creative thinking, Van Hiele's 5 phase learning

1. Introduction

The twenty-first century skills have now become very essential for every individual to adapt to the globalization trend. In contemporary, it is basically adopted as a framework of many organizations, institutes and agencies as workers now require specialized knowledge, creativity and innovation to complete their task. As this trend is showing a rapid rise (Robinson, 2011), many developed countries have transformed their education that focuses on the twenty-first century skills. Most educational organizations are well aware of their role and are thus preparing children to face future challenges (UNESCO, 2010). Thus, acquiring the twenty-first century skills is a necessity to prepare an individual to face the challenges and meet the needs of the future world (UNESCO, 2010).

Creativity is one of the key components in the twenty-first century skills. However, creativity has no definite definition and it depends on the person who defines it. Torrance (1970) has defined creativity as the ability of an individual to produce something novel that can be judged by its value. Mayesky (2010) suggested that creativity is a way of thinking, acting or making something original. It is a combination of many different abilities, skills, motivations and attitudes (Honig, 2006). Creativity is gifted (Kim, 2011). It can be developed throughout a child's development process (Robinson, 2011). It can be enhanced through well constructed didactical activities. According to Rabanos and Torres (2012), a combination of creative development and educational methodology can help to support the development of creative thinking skills. A rigor guidance throughout the activities would bring an effective outcome. Fun element is encouraged in the creativity learning activities. Playing with manipulative concrete materials not only helps students to build concrete concept, it also provides students ample opportunities to unleash their own creativity (Zhang, 2003). Therefore, the current study is carried out to seek answers on how manipulative playing activities can promote creativity throughout a well guided learning environment.

1.1 Creativity in Mathematics Classroom

Creativity did not draw much attention in the Mathematics classroom as many people think that creativity is something that only happens in an arts lesson (Treffinger, Young, Selby & Shepardson, 2002; Sharp, 2004; Bolden, Harries, & Newton, 2011). Previously, the mathematics curriculums only focused on content knowledge. It placed emphasis on rational, critical and sequential thinking despite creative thinking skills (Runco, 2007; Sampascual, 2007; Bernabeu and Goldstein, 2009; Rabanos & Torres, 2012). In Mathematics, creativity is based on one's knowledge base, regardless of one's academic achievement (Hong & Aqui, 2004). When the students are able to solve a problem by splitting it into a few sub-problems, they are regarded as creative as they are able to formulate their own path to work through it (Bolden et al., 2010). It is asserted that a creative student himself is the one who can produce something new to ease his own learning in a Mathematics classroom (Haylock, 1987). Hence, creativity is assumed developed when students construct their own language while handling with mathematical symbols, develop their own understanding of a problem and plan ways to solve and test the reasoning of the solution (Haylock, 1987; Bolden et al., 2010). Sharp (2004) had called for a school mathematics curriculum that would always engage students to think creatively and critically. Enhancing students' creativity is not only to arouse their learning motives (Fisher, 2006), but also to make connection beyond the learning context and widen their comprehension of the learning subject (Qualifications and Curriculum Authority, 2000).

In this study, researcher attempts to investigate students' creativity in geometry learning. In the Malaysian school Mathematics Curriculum, geometry has been introduced since early child education; beginning with Shape and Space. According to Zanzali (2000), geometry learning in the primary school classroom places emphasis on knowing mathematical terms and properties for square, rectangles, triangles, cuboids, cylinders, spheres, cones and pyramids. This is essential for young students to comprehend the physical world (Goos & Spencer, 2003; Erdogan, Akkaya, & Celebi Akkaya, 2009). In fact, several basic skills can be learned through a geometric lesson. Apart from geometrical thinking, development in spatial reasoning is an advantage in gaining other skills, for instance, the cognitive, generalization, analysis and comparison skills. According to researchers, these skills can certainly increase one's creative thinking ability (Erdogan et al., 2009).

However, ambiguity always happens and thus, holding people from being creative. Mueller, Melwani and Goncalo (2011) asserted that many people held ambivalent stances towards creativity. Some researchers found that teachers were reluctant to see students exhibit their curiosity and creativity in the classroom even though they were aware that creativity is the success key in learning (Dawson, D'Andrea, Affinito, & Westby, 1999; Runco, 1989; Westby & Dawson, 1995). The fact is that teachers have difficulties in assessing creativity to support creative development in a Mathematics classroom (Bolden et al., 2011). For example, teachers do not know how to judge the novelty of an idea (Rietzschel, Nijstad, & Stroebe, 2009). Therefore, they often face normative pressure against new ideas (Flynn & Chatman, 2001). This could also be one of the reasons why teachers feel anxious as students may express their ideas freely that could run out from the logical framework (Robinson, 2011). Accordingly, Torrance has developed a test for creativity and it is widely used to measure the "capacity of creativity" of an individual (Kim, 2006).

1.2 Tangram as a Tool for Creativity Development

Abdullah and Zakaria (2012) have pointed out that hands-on exploration activities should be given more emphasis during the teaching and learning of geometry. They highlighted that hands-on exploration activities does not only enable students to foster their creative thinking, but also enables the students' ability in making assumption and argument via the implementation of a geometry project. Hands-on exploration activities also help to provoke students' thoughts, creativity and originality. In response to this view, Copley (2000) has highly recommended that educators incorporate some shape puzzles such as Tangrams, Lego and Fröbel's blocks in geometry teaching and learning activities. With this, it would provide students the opportunities to work with shapes and thus, explore the spatial relation by themselves. An example of a traditional tangram is a set of blocks that contains five triangles, a square and a parallelogram. These can be joined together in various ways to make new figures such as birds and swans (Tian, 2012). Studies found that tangram is a useful manipulative learning aid to establish the concept of geometry (Singh, 2004; Lin, Shao, Wong, Li, & Niramitranon, 2011; Tchoshanov, 2011) and arouse students' imagination, shape analysis, creativity and logical thinking through observation (Olkun et al., 2005; Yang & Chen, 2010).

Mathematics teachers are seldom aware of the advantages of those concrete geometry tools which can be used to foster creativity in students. Moyer (2001) claimed that learning would not happen if teachers only use those tools for fun. In fact, teachers should guide students to enable them to discover and focus on the mathematics concepts involved, while at the same time providing a learning environment that will foster creative thinking in them. The Malaysian educational system is currently undergoing transformation and one of the emphases of the transformation is to create a generation who can think creatively, innovatively and critically (Ministry of Education, 2013). However, the teaching and learning of mathematics in the primary school classroom was often reflected as too teacher-centred (Idris, 2007). Such practice could essentially hinder the development of students' creative thinking ability.

Van Hiele has proposed a model that contains five levels on describing how children's thoughts traverse from one level to the next level, where visual thinking is developed into abstract thinking in a continuous process. These levels are described as Level 1 (Visualisation), Level 2 (Analysis), Level 3 (Informal Deduction), Level 4 (Formal Deduction) and Level 5 (Rigor). There is much research on Van Hiele's geometric model, however that is not the central interest of this study because it is more of concern with promoting student's geometric thinking. This study is more interested to investigate students' creativity through Van Hiele's five sequential phases of learning: Inquiry, Guided orientation, Explication, Free orientation, and Integration (Clements, 2003). Previous studies have found that Van Hiele's model based instruction has helped in developing Grade Six students' creative thinking levels in terms of fluency, originality, titles' being abstract, creative forces list and creativity (Erdogan et al., 2009). Thereafter, this study is conducted to examine if the manipulative concrete materials such as the tangrams as a tool will help young student foster creative thinking provided with Van Hiele's phases of learning environment.

1.3 Purpose of Study

Plenty of previous researches have provided evidence that concrete material teaching and learning tool can indeed result a favor to the students' achievement (Fuys et al., 1988; Bayram, 2004; Trespalacios, 2008; Ojose & Sexton, 2009; Tchoshanov, 2011). However, there were very few related researches being carried out on creativity and geometry learning using tangram among primary school students. Therefore, the present study is attempted to investigate whether the application of van Hiele's 5 phase-based Tangram activities is able to foster students' creativity in terms of Torrance's Figural Test of creative thinking (TTCT) (Torrance, Ball, & Safter, 1992) that is: fluency, originality, elaboration, abstractness of title, and resistance to a premature closure. Fluency indicates an ability to produce a number of figures with a meaningful title which are related to the stimuli; originality shows an ability to produce unusual or unique figures; elaboration indicates the number of details added to enrich and develop on figures; abstractness of title demonstrates the degree a title moves beyond concrete labeling of the figures constructed; and resistance to a premature closure shows the ability of a student to keep an "open mind" in considering a variety of information when completing the figure.

A figural test is used in an effort to reduce linguistic influences among Grade Three students. It includes picture-based tests that use tangram to which Grade Three students can respond to. Furthermore, there is some indication that originality scores may not be easily confounded by fluency on figural tasks (Runco & Alberta, 1985). Figural tasks that involve tangram can be carried out by students in groups before they are tested individually.

The study further examined students' responses to learning experience in tangram activities. Therefore, in order to obtain explanation for the purposes, the addressed research questions are as follow:

- Is there any significant difference in mean scores between the pre- and post -figural test among Grade Three students?
- Is there any significant difference in mean scores between the pre- and post- figural test in five dimensions of Torrance's Figural test of creative thinking among Grade Three students?
- What are the differences in student's constructed figures in terms of five dimensions of Torrance's Figural test of creative thinking before and after intervention?
- What are students' responses to learning experience as a result of their participation in the tangrams activities?

2. Method

2.1 Sample and Sampling Method

Purposive sampling was employed to the selection of study sample to minimize the experimental contamination (Fraenkel & Wallen, 2000). A total number of 144 Grade Three students from a primary school in Kota Kinabalu, Sabah participated as the research sample. Five classes were involved in the study and each class consisted of about 30 students with mix abilities. All participants were given the same topics and they underwent similar intervention. The creativity for every participant was evaluated before and after intervention.

2.2 Research Design

The research design was a single group pre-test and post-test experimental design. This research design involves assessment on the students' creativity based on the figural constructing task which was implemented prior and subsequent to the intervention. The intervention involved geometry lessons in which van Hiele's 5 phases of learning were used in the tangram activities. The topics chosen in the intervention were Two-Dimensional Shapes and Symmetry, part of the topics in the Primary Grade Three Malaysian Mathematics Curriculum Syllabus. The intervention took place for 3 hours.

2.3 Research Instrument

2.3.1 Student's Constructed Figures and Scoring Procedures

In the current study, a piece of paper containing 6 sets of small tangrams was given to the students. Students were allowed to use all the pieces to construct any figures that they perceive as shapes and objects in the world. The participating teacher evaluated the constructed figures based on the five dimensions of Torrance's Figural Test of Creative Thinking (TTCT) (Torrance et al., 1992). The researcher judged the same figure in order to establish the reliability of the scoring. The creativity criterion for the assessment of the students' constructed figures is shown in Table 1.

Table 1. Scoring criteria for students' constructed figures (Adapted and adopted from Torrance et al (1992))

Creativity Criterion	Ability	How it is scored
Fluency	• Produce a large number of figures which match with any objects, shapes or animals (stimuli) found in in the world. • Produce a meaningful title.	"1" point for a constructed figure with a meaningful title and is related to the stimuli. "0" point if the constructed figures could not be understood by the rater, or an abstract figure without a meaningful title.
Originality	• Produce constructed figures that are less expected but that are uncommon or unique.	"1" point for an unusual, special or unique constructed figure. "0" point if the constructed figure is normal, logical or practical.
Elaboration	• Develop and embellish details in constructed figures. Details can be in smaller sub objects that form the main object, different types of colours and etc.	"1" point is given for 1 to 5 details "2" points for 6 to 12 details, and "3" points for 13 to 19 details.
Abstractness of Title	• Produce good titles involves the thinking processes of synthesis and organization. Such a title enables the viewer to see the picture more deeply and richly.	"1" point is given for unusual, special, or unique title. "0" point is given for normal, logical or practical title.
Resistance to Premature Closure	• Keep an open mind and to work on available information from variety of perspectives	"0" point is given for the figure that is constructed in a normal and logical way. "1" point is given for special and unique object. "2" points are given if other objects are detected and related to the stimuli.

The same scoring procedure was repeated to the students' constructed figures after the intervention. The pre- and post- creativity scores were then analyzed quantitatively using SPSS for Windows (version 19.0). Paired sample t-test was employed to see if there is a significant difference between the pre- and post- creativity scores of Grade Three students.

2.3.2 Open-Ended Question

A paper-based open question was administered to the students. Students were required to express their opinions or comments responding to the question: 'I like/dislike tangram activities because …'. Students were asked to reflect on their learning experience or feelings towards tangram activities, and the ways that their experience might have helped in their learning as a result of their participation in the tangrams activities.

2.4 Applying the van Hiele's Five Phases of Learning in Tangram Activities

Van Hiele (1986)'s five phases of learning was applied throughout the Year Three geometry lessons using tangrams. These phases included inquiry, guided orientation, explication, free orientation and integration.

Prior to intervention

Students were requested to cut a small lined and blue-colored tangram square (3 cm x 4 cm) into 7 pieces which contain 5 triangles, 1 square and 1 rhombus. This would be done individually. They were then given a chance to explore and familiarize themselves with the tangram pieces. After the warm up activity, students were asked to manipulate the pieces and form animals or objects that they like and they were required to stick them on a piece of white-colored A4 paper using their own creativity. Students were also asked to create a theme for their constructed figures. Teachers would then collect all the students' individual work.

During intervention

Teacher asked students to form a group of three to four people. Students were then asked to cut a big lined tangram square (6 cm x 8 cm) into 7 pieces. The 7 pieces were numbered on their topsides for reference in directions and discussions of the activities. Students then proceeded to enter the first level of van Hiele's learning phase.

A) Inquiry Phase

At the inquiry phase, students worked cooperatively to explore certain structures of holistic examples and non-examples. In this process, they tried to manipulate, construct and recognize geometric shapes by using a combination of 7 tans tangram. Furthermore, they were required to observe some concrete objects in their surroundings, such as the 2-D front view of the ruler, eraser, pen, bottle, food container lid and paper clips to describe the characteristics of polygons and non polygons. Throughout the process, students were familiarized with a variety of geometric shapes.

This activity leads students to think creatively to make a new shape by joining different tangram pieces. For instance, two small right angle triangles will become a square, a rectangle, a bigger triangle, a rhombus, a parallelogram, a butterfly, and etc. By playing with the tangram puzzles, students use their visual sense to match the puzzles. This will indeed stimulate their creativity.

B) Guided Orientation

In this phase, the students were asked to examine the properties of geometric shapes. With teacher's guide, they explored the 2-D geometric shapes given. This process was guided carefully and they then recorded the properties of the shape. For instance, while examining an equilateral triangle, students found some interesting properties such as three equal sides; three equal angles and three symmetries. Apart from that, natural objects such as leaves and flowers were also used in this stage for students to learn about the symmetry line for irregular shape. These natural objects were then folded into halves to show its lines of symmetry. This activity engages students to enhance their imagination and hence their creativity by requesting them to give some other examples and their symmetry line.

C) Explication

The phase of explication introduces new terminology of polygons and their properties. Students were taught to describe the polygon using appropriate mathematics language, such as congruent, corners, straight sides, right angles, face, equilateral triangle, square, quadrilateral, regular and irregular polygons, pentagon, hexagon, heptagon and octagon.

D) Free Orientation

After their acquaintance with special terminologies used to describe the polygons, students explored new geometric shapes. Here is the stage where students can unleash their creativity completely by doing composite mission. This helps students to find their own way in the network of relations. They tried to make several trials in joining the tangram pieces to form some other figures and shapes that can be found in their surrounding, while at the same time, referring to a photocopy of various shapes provided. For example, by knowing the properties of a pentagon, students tried to investigate and find out specific properties for a new shape, such as hexagon, heptagon and octagon. Students were given ample opportunity for free play and sharing of their group's creations. Students also worked cooperatively to form figures of animals or other objects by using 7 pieces (tans).

E) Integration

At this stage, students were required to summarize the properties of a geometric shape. They generated an overview of what they have learned about a geometric shape. Their efforts of making generalization were regarded as creative as they formulated their own conclusion for themselves. For example, students composed a rule that an octagon has eight equal sides; its corners are the same–all are equal angles; and it can be folded to exhibit 8 line symmetry. Students also learned about other polygons such as heptagon in a similar manner.

After the intervention

Students were then individually asked to cut a small lined and green-colored tangram square (3 cm x 4 cm) into 7 pieces and to form figures that they like. Their assembled figures were then pasted on a piece of blank white-colored A4 paper and an appropriate theme was given. Teachers then collected all the students' work.

At the end of the lesson, students were asked to give their views on the use of tangram activities that they had experienced in written form.

3. Data Analysis

3.1 Analysis of Students' Level of Creativity

3.1.1 Inter Rater Reliability

The constructed figures were rated independently by an assigned mathematics teacher and the researcher. Both of the raters had attended an extensive training in scoring the five dimensions of Torrance's Figural Test of Creative Thinking (TTCT). Before starting the scoring, each rater scored the same set of 40 students's constructed figures independently by following the scoring criteria given as shown in Table 1. Disagreements in scoring the student's constructed figures were resolved by a discussion among the raters. The inter-rater reliability was obtained using Kappa statistic for determining the rating consistency among raters. As a rule of thumb, Kappa statistic was referred to the benchmark scale proposed by Landis and Koch (1977).

Table 2 shows the Cohen's Kappa Inter-rater Reliability for Pre and Post TTCT score. Every item that is rated by two raters was calculated for the degree of agreement and found to be statistically significant ($p<0.050$). The obtained Kappa statistics indicated that both raters have mostly substantial agreement (0.61-0.80) and almost perfect agreement (0.81-1.00) on the score rated respectively. This result was concluded at 95% of confidence level.

Table 2. Cohen's Kappa Inter Rater Reliability for Pre- and Post- TTCT Score

Symmetric Measures						
Rater 1 * Rater 2 N = 40	Pre-TTCT Measure of Agreement - Kappa			Post-TTCT Measure of Agreement - Kappa		
	Value	Asymp. Std. Error[a]	Approx. Sig.	Value	Asymp. Std. Error[a]	Approx. Sig.
Fluency	0.655	0.320	0.000	0.655	0.320	0.000
Originality	0.796	0.096	0.000	0.826	0.096	0.000
Elaboration	0.908	0.090	0.000	0.767	0.112	0.000
Abstractness of Title	0.655	0.320	0.000	0.762	0.112	0.000
Resistance to Premature Closure	0.708	0.094	0.000	0.638	0.096	0.000

a. Not assuming the null hypothesis.

3.1.2 Analysis of Open-Ended Question

The students' responses were analyzed to investigate students' experiences during the tangram activities and the process of learning. The validity of the open-ended response was determined by agreement between a Mathematics teacher as an independent rater and the researcher.

4. Results

4.1 Students' Level of Creativity in Five Dimensions of TTCT

Overall, the result in Table 3 showed that there were significant differences ($p<0.050$) in mean scores between pre- and post-figural test. Based on an in-depth analysis regarding the five dimensions of Torrance's creativity, the statistics given showed no significant difference ($p>0.050$) in terms of fluency ($p=0.319$) and abstractness of title ($P=0.145$). However, there were statistical significances ($p< 0.050$) in terms of originality, elaboration and the resistance to premature closure between the pre- and post- figural test. Generally, students' scores in terms of elaboration have increased after intervention. However, the finding indicated a dropping trend in terms of originality and resistance to premature closure after the intervention. This conclusion was made at the confidence level of 95%.

Table 3. Paired samples statistics for creativity score

Paired Samples Statistics								
N = 144		Mean	Std. Deviation	Paired Differences		t	df	Sig. (2-tailed)
				Mean	Std. Deviation			
Fluency (max 1)	Pre	0.951	0.216	-0.021	0.250	-1.000	143	0.319
	Post	0.972	0.165					
Originality (max 1)	Pre	0.535	0.501	0.174	0.630	3.310	143	0.001
	Post	0.361	0.482					
Elaboration (max 3)	Pre	1.174	0.380	-0.646	0.620	-12.504	143	0.000
	Post	1.819	0.483					
Abstractness of title (max 1)	Pre	0.090	0.288	-0.056	0.455	-1.466	143	0.145
	Post	0.146	0.354					
Resistance to Premature closure (max 3)	Pre	0.597	0.618	0.271	0.813	3.999	143	0.000
	Post	0.326	0.589					
Total (max 9)	Pre	3.347	1.047	-0.278	1.416	-2.353	143	0.020
	Post	3.625	1.194					

**Significant at $p<0.05$*

4.2 Qualitative Analysis on Student's Constructed Figures

The following shows four examples of students' constructed figures using 7 tans that were produced on a piece of A4 paper. The creativity of students before and after intervention was compared in terms of fluency, originality, elaboration, abstractness of title and resistance to premature closure. The scores agreed by both raters were shown in bracket ( ).

Example 1 (Student A)

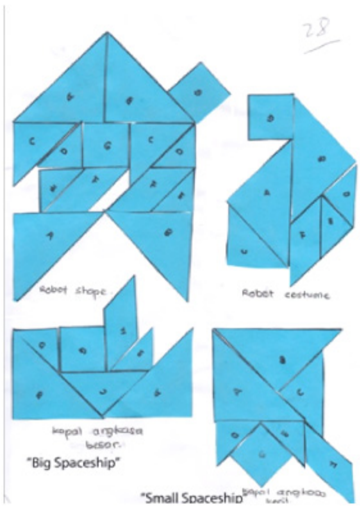

Figure 1(a). Pre-figure of Student A

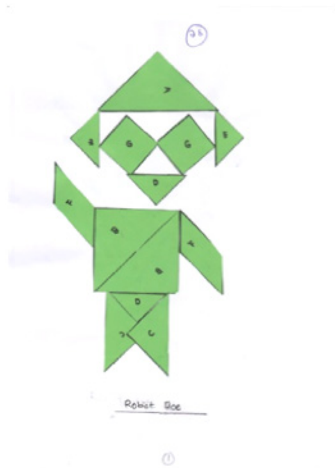

Figure 1(b). Post-figure of Student A

Looking at the pre-figure as shown in Figure 1(a), student A has shown very little fluency (0 point) and elaboration (1 point) as it was quite abstract. Apparently, raters could not make a linkage between the title and the constructed object. However, the creativity of the student could not be denied as the originality of the object, such as 'Robot Shape' that was constructed after intervention through the student's imagination was indeed unique. When we compare the figure constructed after intervention (Figure 1(b)), even though it was the same category of figure (Robot), yet, student A was already capable of showing his ability to construct something concrete, complex, vivid and unique. This has indeed increased the fluency (1 point), elaboration (2 points) and originality dimension (1 point) of TTCT. The overall arrangement of tans apparently demonstrated a very clear picture of a robot which was named with a smart title – Robot Doe (abstractness of title- 1 point).

Example 2 (Student B)

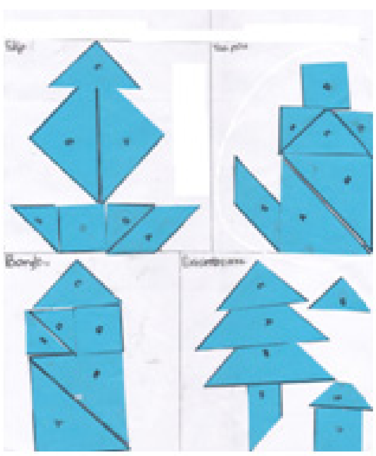

Figure 2(a). Pre-figure of Student B

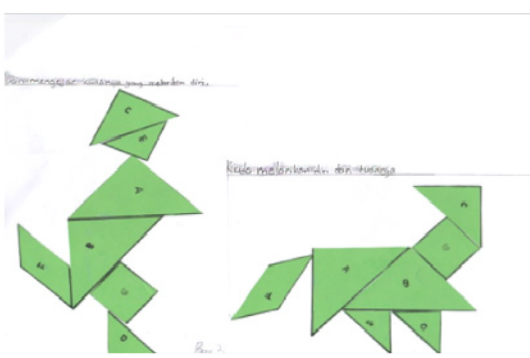

Figure 2(b). Post-figure of Student B

Both the figures showed a piece of art of student B before (Figure 2(a)) and after (Figure 2(b)) intervention. The pre-figure showed fluency (1 point) but less originality (0 point) as the items constructed were very common which can be found in our daily physical world. The abstractness of the title was lacking since the title generated was quite direct and showed less abstractness (0 point). Moreover, the four objects created in the pre-figure were quite simple and have fewer details (Elaboration-1 pont). As compared to the second figure, the latter was obviously better with the whole arrangement of tans. The second constructed figure manifested a vivid image story along with its title – "An owner is chasing his fled horse, the horse is fleeing from its owner". It appeared that this student had improved the dimensions of elaboration (2 points), originality (1 point), and the abstractness of title (1 point) in his constructed figure.

Example 3 (Student C)

Figure 3(a). Pre-figure of Student C

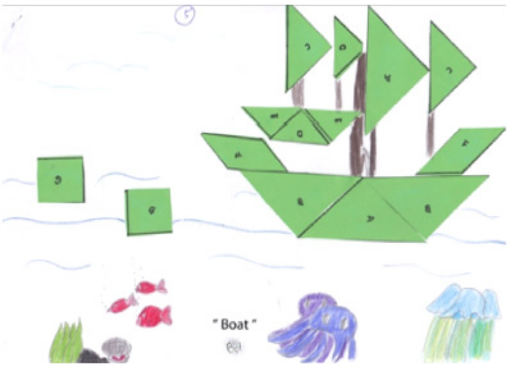

Figure 3(b). Post-figure of Student C

Student C showed fluency (1 point) in making a clear object in both constructed figures. The factory produced in Figure 3(a) expresses elaboration in detail (2 points) but it lacks originality (0 point). Figure 3(b) did perform better since it does not only show fluency (1 point) and details (2 points), but also originality (1 point) by including the figure with the sailing boat masts. However, student C was less creative as he could not generate a unique and abstract title (0 point) for both the pre- and post-figures. Nevertheless, student C did put in some efforts to enrich the meaning of the constructed figures in Figure 3(b) (Resistance to Premature Closure-2 points).

Example 4 (Student D)

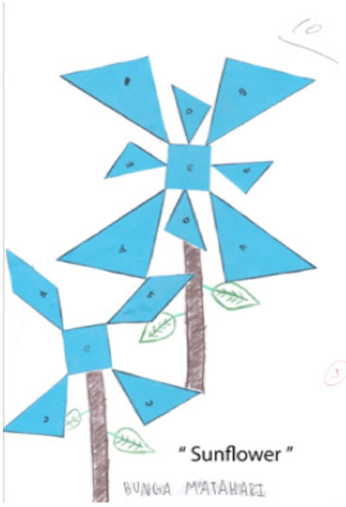

Figure 4(a). Pre-figure of Student D

Figure 4(b). Post-figure of Student D

Figure 4(a) showed fluency (1 point) and elaboration (1 point) as this student was able to arrange big and small petals in a meaningful way. It was quite unique (originality-1 point) since the common perception of sunflower should be a circle in the middle. Efforts were shown by including the stem and leaves to make the figure more meaningful. However, the title generated is very direct with regards to the object (abstractness of title- 0 point). By comparing it to the second figure in Figure 4(b), the latter apparently looked better as this student can make many small people and mountains, using triangles to represent a girl's skirt and mountain, while using squares to represent a boy. This is indeed a super creative imagination; representing and differentiating between a boy and a girl using triangle and square shapes. The combination of the tans and pencil drawing has enriched the overall picture along with a very unique title – "Photo Taking of My Family at a Mountain". It appeared that this student had improved the dimensions of elaboration (2 points), and the abstractness of title (1 point) in his/her constructed figure.

By comparing the four students' examples of pre- and post- figures, it is proven that the students' creativity have improved on the basis of five dimensions of Torrance's Figural test of creative thinking. The comparison showed that students' capability in expressing ideas in figure forms and generating abstractness of title has improved and was surprisingly impressive. For instance, students can differentiate genders by using a simple shape; make a meaningful title reflecting the story behind the figure; build their own abstract character like Mr. Robot Doe, and etc. Students' potential to creativity was revealed in these four examples after a geometry lesson using tangrams.

4.3 Student's Perceptions on Tangram Creative Activities

Almost all the students responded that they liked playing with tangram pieces and they enjoyed creating their own design using their imaginations. They responded that: "I like playing with tangram pieces, it looks like a puzzle and origami;", "I can make my own design that I love;", "I like to do cut and paste activities;", "Many shapes can be designed from a piece of tangram set;" and "I love making shapes of animals and insects using my own imaginations".

Students can arrange the pieces in several ways and hence they enjoyed finding new ways in their creation. They responded that: - "I have many ways to arrange the tangram pieces;" and "I can create a Robot which is different from my friend".

Students also experienced the joy of expressing themselves openly. They pointed out that: "I can create whatever I wish and show others my new creation".

They also felt that the tangram activities increase their knowledge about shapes. Some of the related responses were: - "I can learn and name many shapes;", "I love learning many new shapes at a time;", "Much can be learned from tangram activities;", and "It helps me to understand the difference between a polygon and a non-polygon".

Students generally felt that the activities can help them to develop their potentials to think differently. Their feedbacks were:-"the tangram activates my brain to think of shapes which are different from the others;", "It tests my mind to think of something different".

With these activities, students became aware of their natural potential to be creative with the use of tangram, as they stated: "I was able to produce a design that I have never made or even thought of making;", "I can create a shape which was previously unknown to me, eg. Robot Doe and show it to my friends".

Many students expect more tangram activities in their Mathematics class. They wrote:-"I am hoping to see tangram activities in the future mathematics lesson;" and "I am interested in the way the teacher teaches using the tangram".

In terms of execution of tangram puzzle activities, most students felt that the 7 tans tangram was easy to operate and thus, they can create a lot of geometry shapes and interesting figures. They responded that:- "I can create a variety of interesting figures of a polygon/person/animal/bird/robot/fish/house from a set of tangram".

On the whole, students expressed that the tangram activities had provided an opportunity for them to think creatively.

5. Discussion

The current study has attempted to perform empirical evidence on the use of Tangram as a tool in promoting students' creativity. After a series of statistical analysis, the finding revealed that creativity can be fostered through the instruction using Tangram which was based on van Hiele's five phases of learning.

During the play with tangram, students demonstrated their creativity in constructing figural products instead of learning the concept of 2-dimentional geometry shape itself. The “Inquiry phase” and “Direct Orientation phase” led students to explore and discover new shapes and figures by joining different tangram pieces. Fitting tangram pieces to form geometry shapes and figures help students to be aware of the features of sides and angles of the pieces. Such hands-on activities enable students to develop knowledge and properties of polygons and their creativity. During the explication phase, students used the introduced terminology to name different types of polygons and figures produced during their group activities and to communicate their creative thinking. In the fourth phase which is the free orientation phase, students find their own way to investigate and find out specific properties for a new shape. In the fifth or final phase, that is the integration phase, students were given opportunities to pull together what they have learned, by making a generalization about their own constructed figures. As a whole, creativity is fostered when students are involved in tangram activities using imagination, playing with 7 tans, and exploring it. When students go at their own pace creating their own shapes in a relaxed learning environment, they are likely to become more creative.

The use of tangram which was incorporated in van Hiele’s five phases of learning allows the teacher to foster the creative potential of students more broadly. This was shown by four randomly selected examples of students’ works which were found to have impressively improved in some dimensions of TTCT. The post-constructed figures were unique if compared to the simple and common one constructed in the pre-TTCT figural test. Moreover, these figures showed that students used their own imagination to showcase their creativity. Other than that, students also showed very fine creativity in constructing an abstract title, such as “an owner is chasing his fled horse, the horse is fleeing from its owner”, “Photo Taking of My Family at a Mountain” and “Robot Doe”. The title of “Robot Doe” was named by the student himself as he created this new virtual creature. In particular, the student’s work of “Photo Taking of My Family at a Mountain” showed a great resistance to premature closure, as the whole picture was very complete, with some additional drawing, which absolutely brought this picture into life. Significantly, this student can even differentiate between two genders in the form of triangles or squares, which indeed represented the way a child view the symbol for male and female using geometric shapes. In line with the result, Garaigordobil and Berrueco (2011) also obtained a positive significant result in improving students’ creative thinking skills after applying a new intervention program in early childhood education through play. Six of the students’ impressive art pieces before and after were taken for qualitative analysis to compare the improvement due to tangram activity. In average, students showed very good changes in terms of creativity. For instance, they showed a good sense in making imaginative title after intervention, part of them can provide a very unusual figure with tangram and enrich it by adding colours or drawings. Align with the result, Brunkalla (2009) also found that the use of concrete manipulatives such as the Fröbel’s blocks was effective in fostering learner’s creativity in geometry.

However, it is still premature to suggest that van Hiele’s learning phase using Tangram is perfectly a success as further investigation is needed to establish better validated significant finding. The in-depth analysis about the five dimensions of Torrance’s creativity found that the applied intervention was only significant in improving students’ elaboration, no significant changes in students’ fluency and abstractness of title, and significant dropping performance in originality and resistance to premature closure. The dropping performance in originality and resistance to premature closure may be due to many reasons. It could be caused by the fact that the students had learned to build some figures that were produced during group activities which act as an induction to their creativity. However, certain students lack imagination in creating new figures during the post-figural test, and hence, most of those students constructed the same figures being produced during the group activities. This contributes a significant drop in students’ originality and resistance to premature closure in constructing unique figures. However, this could also be one of the factors that the students’ elaboration had increased significantly as they were able to add relevant details to the constructed figures.

Other than that, the study also found that there was no significant increase in the students’ ability to construct a number of figures with a meaningful and unique title that involve thinking beyond the learning context. Creativity can be developed in a proper creative development. However, it is probably not the case for Grade Three students. Gardner (1982) argued that school children showed a decline in their artistic creativity as compared to preschool children as they have begun to learn conformity. Smith and Carlsson (1983) also argued that it is still premature for children younger than the age of 10 to possess a true sense of creativity since they are more focused on materials that have been incorporated into their private self and are very dependent on accidental impressions. This is supported by Axtell (1966), Nash (1974), Williams (1976), Torrance (1977), Kang (1989), Marcon (1995), and Timmel (2001) which also asserted a decline of creativity when conformity and socialization are taught in Western society starting from fourth grade.

Alternatively, incorporating creativity into a geometry lesson contributes to students' positive perception towards geometry learning. An analysis of students' responses to the open-ended questions showed that students had obtained inspiration to create something new. They enjoyed learning when they discovered new things and when they were given opportunities to unleash their creativity. They gained an interest and motivation in making new shapes besides having widened their comprehension about geometric shapes. Students had fun during the process of manipulating the 7 tans. They found the freedom in expressing their ideas without being bound by the rules and definite answers. This is in line with Drickey (2006)'s study who found that manipulative activities made many students feel enjoyable and "want to learn more". In order to encourage students to persistently engage actively in expressing their creativity, Rabanos & Torres (2012) suggested that the teacher should be well-trained with multiple thinking skills, especially creative thinking skill, incorporating them with strategies and methods in the learning activity.

6. Conclusion

In conclusion, tangram has been proven as a useful concrete manipulative tool in learning geometry and it is able to help develop better creativity when integrated with van Hiele's five Phases of learning. Students get to maximize the given freedom to exert their imagination and creativity with the tangrams throughout the geometry lessons. Some students showed great improvement in their creativity level in the figural test. The students' testimonials also reflected the use of tangram as a good medium to showcase their creativity and enhance their geometric concept. Nevertheless, there is still insufficient evidence to show the effectiveness in increasing creativity in terms of the five dimensions of Torrance's Figural Test of creative thinking: fluency, originality, elaboration, abstractness of title, and resistance to a premature closure. Future investigation is required to overcome the limitation of the study. To gain an insight into the corresponding of the Torrance's five dimensions of creativity, it is suggested that future investigation should design a study for a larger sample from grade one to grade six students. Despite previous studies having discovered a pattern of changes in creativity corresponding to age, it is still possible to obtain different outcomes. It is certainly a very interesting finding since the creativity of a student is unpredictable, and it varies among students of different grades. A further limitation in this study is noted in the lack of student interviews as a data source to support the findings of open-ended question and to gain more insight into student's constructed figures.

Mathematics teachers should reflect on their practices and beliefs in order to optimize opportunities for children to develop their creativity. As the early childhood years is the foundation for later learning, specific opportunities for the development of geometry creativity should be provided in the setting of the early education. Current practices in the Malaysian primary schools appear to provide rare opportunities for the development of creativity. Just as in the pre-school setting, rich learning experiences that enhance geometry creativity should be provided in the primary school classroom through sequences of hands-on exploration and concrete experience, just as what has been carried out in this study.

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References

Abdullah, A. H., & Zakaria, E. (2012). The activities based on Van Hiele's phase-based learning: Experts' and pre-service teachers' views. *Journal of Mathematics and Statistics*, *8*, 385-395. http://dx.doi.org/10.3844/jmssp.2012.385.395

Axtell, J. (1966). Discontinuities in the perception of curiosity in gifted preadolescents. *Gifted Child Quarterly*, *10*, 78-82. http://dx.doi.org/10.1177/001698626601000206.

Bayram, S. (2004). *The effect of instruction with concrete models on eighth grade students' geometry achievement and attitudes toward geometry*. MSc Thesis, Middle East Technical University. Retrieved from http://etd.lib.metu.edu.tr/upload/12605556/index.pdf

Bernabeu, N., & Goldstein, A. (2009). *Creativity and Learning: the game as the pedagogical tools*. Cited in Rabanos, N. L., & Torres, P. A. (2012), Effects of a program for developing creative thinking skills. *Electronic Journal of Research in Educational Psychology*, *10*(3), 1139-1158. Retrieved from http://www.investigacion-psicopedagogica.org/revista/new/english/ContadorArticulo.php?793

Bolden, D. S., Harries, A. V., & Newton, D. P. (2010). Pre-service primary teachers' conceptions of creativity in Mathematics. *Educational studies in mathematics*, *73*(2), 143-157. http://dx.doi.org/10.1007/s10649-009-9207-z

Brunkalla, K. (2009). How to increase mathematical creativity – an experiment. *The Montana Mathematics Enthusiast*, *6*(1&2), 257- 266. Montana Council of Teachers of Mathematics & Information Age Publishing. Retrieved from http://www.math.umt.edu/tmme/vol6no1and2/TMME_vol6nos1and2_article19_pp.257_266.pdf

Clements, D. H. (2003). Teaching and Learning Geometry. In K. Jeremy, W. G. Martin, & S. Deborah (Eds.), *A Research Companion to Principles and Standards for School Mathematics* (pp. 151-178). Reston, VA: National Council of Teachers of Mathematics.

Copley, J. V. (2000). Geometry and Spatial Sense in the Early Childhood Curriculum. Reprinted from *The Young Child and Mathematics,* chapter 6, 2000. In *A reading from the CD accompanying Developmentally Appropriate Practice in Early Childhood Programs Serving Children from Birth through Age 8* (3rd ed.).

Dawson, V. L., D' Andrea, T., Affinito, R., & Westby, E. L. (1999). Predicting creative behavior: A reexamination of the divergence between traditional and teacher-defined concepts of creativity. *Creativity Research Journal*, *12*(1), 57-66. http://dx.doi.org/10.1207/s15326934crj1201_7

Drickey, N. (2006). Learning technologies for enhancing student understanding of mathematics. *International Journal of Learning*, *13*(5), 109-116.

Erdogan, T., Akkaya, R., & Çelebi Akkaya, S. (2009). The Effect of the Van Hiele Model Based Instruction on the Creative Thinking Levels of 6th Grade Primary School Students. *Educational Sciences: Theory & Practice*, *9*(1), 181-194. Retrieved from http://files.eric.ed.gov/fulltext/EJ837779.pdf

Fisher, R. (2006). Expanding minds: Developing creative thinking in young learners. *CATS: The IATEFL Young Learners SIG journal, Spring*, 5-9. Retrieved from http://www.teachingthinking.net/thinking/web%20resources/robert_fisher_expandingminds.htm

Flynn, F. J., & Chatman, J. A. (2001). Strong cultures and innovation: Oxymoron or opportunity? In T. Holden, N. Sparrow, & W. Starbuck (Eds.), *International Handbook of Organizational Culture and Climate* (pp. 263-287). Sussex: John Wiley & Sons.

Fraenkel, J. R., & Wallen, N. E. (2000). *How to design and evaluate research in education*. Boston: McGraw-Hill.

Fuys, D., Geddes, D., & Tischler, R. (1988). The van Hiele model of thinking in geometry among adolescents. *Journal for Research in Mathematics Education, Monograph*, *3*. http://dx.doi.org/10.2307/749957

Garaigordobil, M., & Berrueco, L. (2011). Effects of a play program on creative thinking of preschool children. *The Spanish Journal of Psychology*, *14*(2), 608-618. http://dx.doi.org/10.5209/rev_SJOP.2011.v14.n2.9

Gardner, H. (1982). *Art, mind, and brain: A cognitive approach to creativity*. New York: Basic Books.

Goos, M., & Spencer, T. (2003). Properties of shape, mathematics-making waves. In M. Goos, & T. Spencer (Eds.), *Proceedings of the Nineteenth Biennial Conference of the Australian Association of Mathematics Teachers* (pp. 424-434). Adelaide: AAMT Inc.

Haylock, D. W. (1987). A framework for assessing mathematical creativity in school children. *Education Studies in Mathematics*, *18*(1), 59-74. http://dx.doi.org/10.1007/BF00367914

Hong, E., & Aqui, Y. (2004). Cognitive and motivational characteristics of adolescents gifted in mathematics: Comparisons among students with different types of giftedness. *Gifted Child Quarterly*, *48*(3), 191-201. http://dx.doi.org/10.1177/001698620404800304

Honig, A. S. (2006). Supporting creativity. *Early Childhood Today*, *20*(5), 13-14.

Idris, N. (2007). The effects of geometers' sketchpad on the performance in geometry of Malaysian students' achievement and van Hiele geometric thinking. *Malaysian Journal of Mathematics Sciences*, *1*(2), 169-180. Retrieved from http://psasir.upm.edu.my/12566/1/UPM(MJMS)v1(2)2_(crop).pdf

Kang, C. (1989). *Gender differences in Korean children's responses to the Torrance Tests of Creative Thinking from first to sixth grade* (Unpublished master's thesis). University of Wisconsin, Madison, WI.

Kim, K. H. (2006). Can we trust creativity tests? A review of the Torrance Tests of Creative Thinking (TTCT). *Creativity Research Journal*, *18*(1), 3-14. http://dx.doi.org/10.1207/s15326934crj1801_2

Kim, K. H. (2011). The creativity crisis: The decrease in creative thinking scores on the Torrance Tests of Creative Thinking. *Creativity Research Journal*, *23*(4), 285-295. http://dx.doi.org/10.1080/10400419.2011.627805

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*, 159-174. http://dx.doi.org/10.2307/2529310

Lin, C. P., Shao, Y. J., Wong, L. H., Li, Y. J., & Niramitranon, J. (2011). The impact of using synchronous collaborative virtual tangram in children's geometric. *Turkish Online Journal of Educational Technology*, *10*(2), 250-258. Retrieved from http://www.editlib.org/p/53383

Marcon, R. A. (1995). Fourth-grade slump: The cause and cure. *Principal*, *74*(5), 16-17.

Mayesky, M. (2010). *Creative Activities for Young Children* (10th ed.). United State: Cengage Learning.

Ministry of Education. (2013). *Malaysia Education Blueprint 2013-2025: Preschool to Post-Secondary Education*. Kuala Lumpur: Kementerian Pelajaran Malaysia.

Moyer, P. S. (2001). Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational Studies in Mathematics*, *47*(2), 175-197. http://dx.doi.org/10.1023/A:1014596316942

Mueller, J. S., Melwani, S., & Goncalo, J. A. (2011). *The bias against creativity: Why people desire but reject creative ideas*. Retrieved from http://digitalcommons.ilr.cornell.edu/articles/450

Nash, W. R. (1974). The effects of a school for the gifted in averting the fourth grade slump in creativity. *Gifted Child Quarterly*, *18*, 168-170.

Ojose, B., & Sexton, L. (2009). The effect of manipulative materials on mathematics achievement of first grade students. *The Mathematics Educator*, *12*(1), 3-14.

Olkun, S., Altun, A., & Smith, G. (2005). Computers and 2D geometric learning of Turkish fourth and fifth graders. *British Journal of Educational Technology*, *36*(2), 317-326. http://dx.doi.org/10.1111/j.1467-8535.2005.00460.x

Qualifications and Curriculum Authority. (2000). *Curriculum Guidance for the Foundation Stage*. London: QCA.

Rabanos, N. L., & Torres, P. A. (2012). Effects of a program for developing creative thinking skills. *Electronic Journal of Research in Educational Psychology*, *10*(3), 1139-1158. Retrieved from http://www.investigacion-psicopedagogica.org/revista/new/english/ContadorArticulo.php?793

Rietzschel, E., Nijstad, B., & Stroebe, W. (2009). The selection of creative ideas after individual idea generation: Choosing between creativity and impact. *British Journal of Psychology*, *0*, 1-23.

Robinson, K. (2011). *Out of our minds: Learning to be creative* (2nd ed.). United Kingdom: Capstone Publishing Ltd.

Runco, M. A., & Alberta, R. S. (1985). The reliability and validity of ideational originality in the divergent thinking of academically gifted and non-gifted children. *Educational and Psychological Measurement*, *45*, 483-501.

Runco, M. A. (1989). Parents' and teachers' ratings of the creativity of children. *Journal of Social Behavior & Personality*, *4*(1), 73-83.

Runco, M. A. (2007). *Creativity theories and theme: Research, development and practice*. Burlington, MA: Elsevier.

Sampascual, G. (2007). *Educational Psychology* (Vol. 2). Madrid: UNED.

Sharp, C. (2004). Developing young children's creativity: What can we learn from research? *TOPIC*, *32*, 5-12. Retrieved from http://www.nfer.ac.uk/nfer/publications/55502/55502.pdf

Singh, M. (2004). *Modern Teaching of Mathematics*. Anmol Publications Pvt Ltd. New Delhi.

Smith, G. J. W., & Carlsson, I. (1983). Creativity in early and middle school years. *International Journal of Behavioral Development*, *6*(2), 167-195. http://dx.doi.org/10.1177/016502548300600204

Tchoshanov, M. (2011). Building students' mathematical proficiency: Connecting mathematical ideas using the tangram. *Learning and Teaching Mathematics*, *10*, 16-23. Retrieved from http://www.amesa.org.za/amesal_n10_a2.pdf

Tian, X. X. (2012). *The art and mathematics of tangrams* (pp. 553-556). Conference Proceedings of Bridges Towson: Mathematics, Music, Art, Architecture, Culture, Towson University, Maryland, USA.

Timmel, J. L. (2001). Creativity and acculturation: Psychological and cultural effects on the divergent thinking of Cuban preadolescent immigrants entering the United States. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *61*(9-A), 34-68.

Torrance, E. P. (1970). *Encouraging creativity in the classroom*. Dubuque, Iowa: W. C. Brown Co.

Torrance, E. P. (1977). *Creativity in the classroom*. Washington, DC: National Education Association.

Torrance, E. P., Ball, O. E., & Safter, H. T. (1992). *Torrance Tests of creative thinking: Streamline scoring guide figural A and B*. Bensenville, IL: Scholastic Testing Service, Inc.

Treffinger, D. J., Young, G. C., Selby, E. C., & Shepardson, C. A. (2002). *Assessing creativity: A guide for educators*. Storrs, CT: The National Research Center on the Gifted and Talented.

Trespalacios, J. H. (2008). *The effects of two generative activities on learner comprehension of part-whole meaning of rational numbers using virtual manipulatives*. (Unpublished doctorate Thesis, Institute and State University in Partial Fulfillment).

UNESCO. (2010). *Current Challenges in Basic Science Education*. Retrieved from http://unesdoc.unesco.org/images/0019/001914/191425e.pdf

Van Hiele, P. M. (1986). *Structure and insights: A theory of mathematics education*. Orlando, FL: Academic Press.

Westby, E. L., & Dawson, V. L. (1995). Creativity: Asset or burden in the classroom? *Creativity Research Journal*, *8*(1), 1-10. http://dx.doi.org/10.1207/s15326934crj0801_1

Williams, F. E. (1976). Rediscovering the fourth-grade slump in a study of children's self-concept. *Journal of Creative Behavior*, *10*(1), 15-28. http://dx.doi.org/10.1002/j.2162-6057.1976.tb00134.x

Yang, J. C., & Chen, S. Y. (2010). Effects of gender differences and spatial abilities within a digital pantomimes game. *Computers and Education*, *55*(3), 1220-1233. http://dx.doi.org/10.1016/j.compedu.2010.05.019

Zanzali, N. A. A. (2000). *Designing the mathematics curriculum in Malaysia: Making mathematics more meaningful*. Skudai: Universiti Teknologi Malaysia.

Zhang, E. (2003). *Construct knowledge and nurture creativity education theory and case studies*. Seminar: Robotics in Classroom, Hong Kong, China. Retrieved from http://hdl.handle.net/10722/44027

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